Developing the World's Leading Geothermal Resources:
A Case Study of the Geothermal Clean Energy Investment Project in Indonesia

ESMAP RENEWABLE ENERGY TRAINING PROGRAM
GEOTHERMAL ENERGY

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Washington DC

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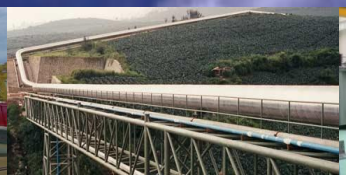
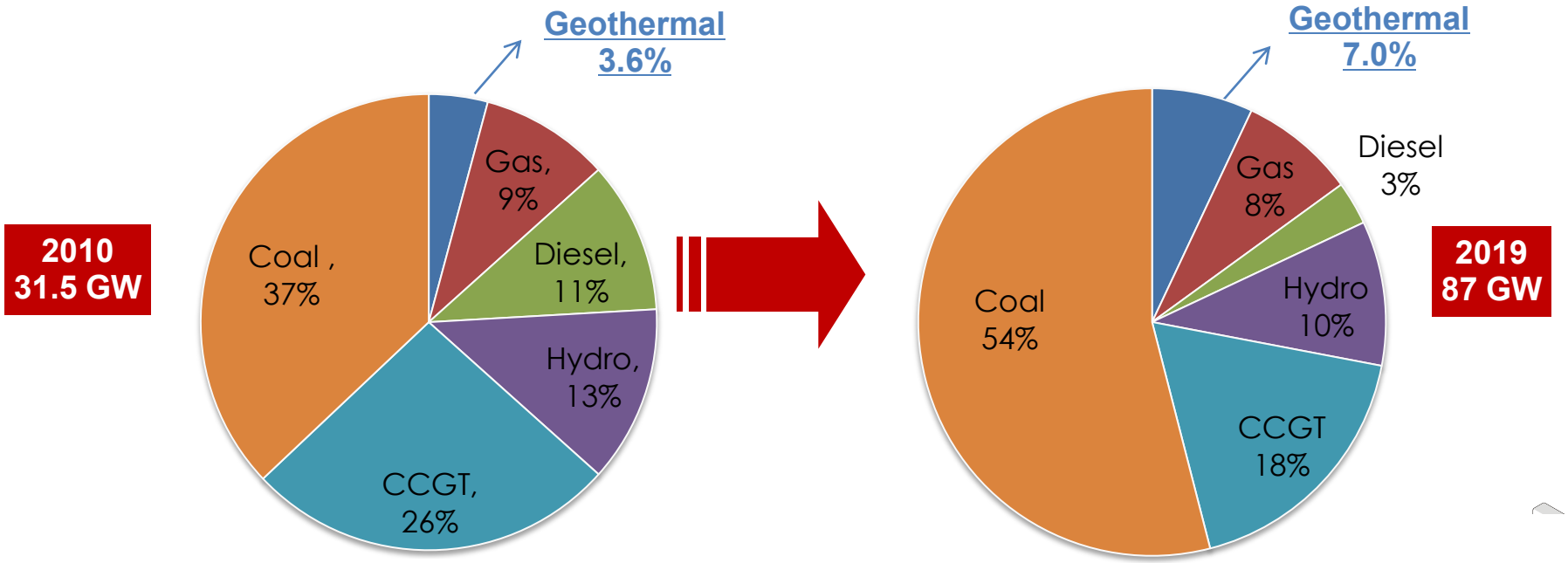
Background and Sector Issues



Key Challenges Facing Indonesia's Power Sector

- Looming power shortages in face of growing economy
- Momentous investment needs of $4-$5 billion annually to meet demand
- Only about 70% of population with formal access to electricity
- Lack of clear vision due to legal, policy and regulatory uncertainties
- Sub-optimal power generation mix is dominated by fossil fuels - with heavy reliance on diesel and substantial expansion of coal underway with significant environmental impact



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Why Develop Geothermal?

ENERGY

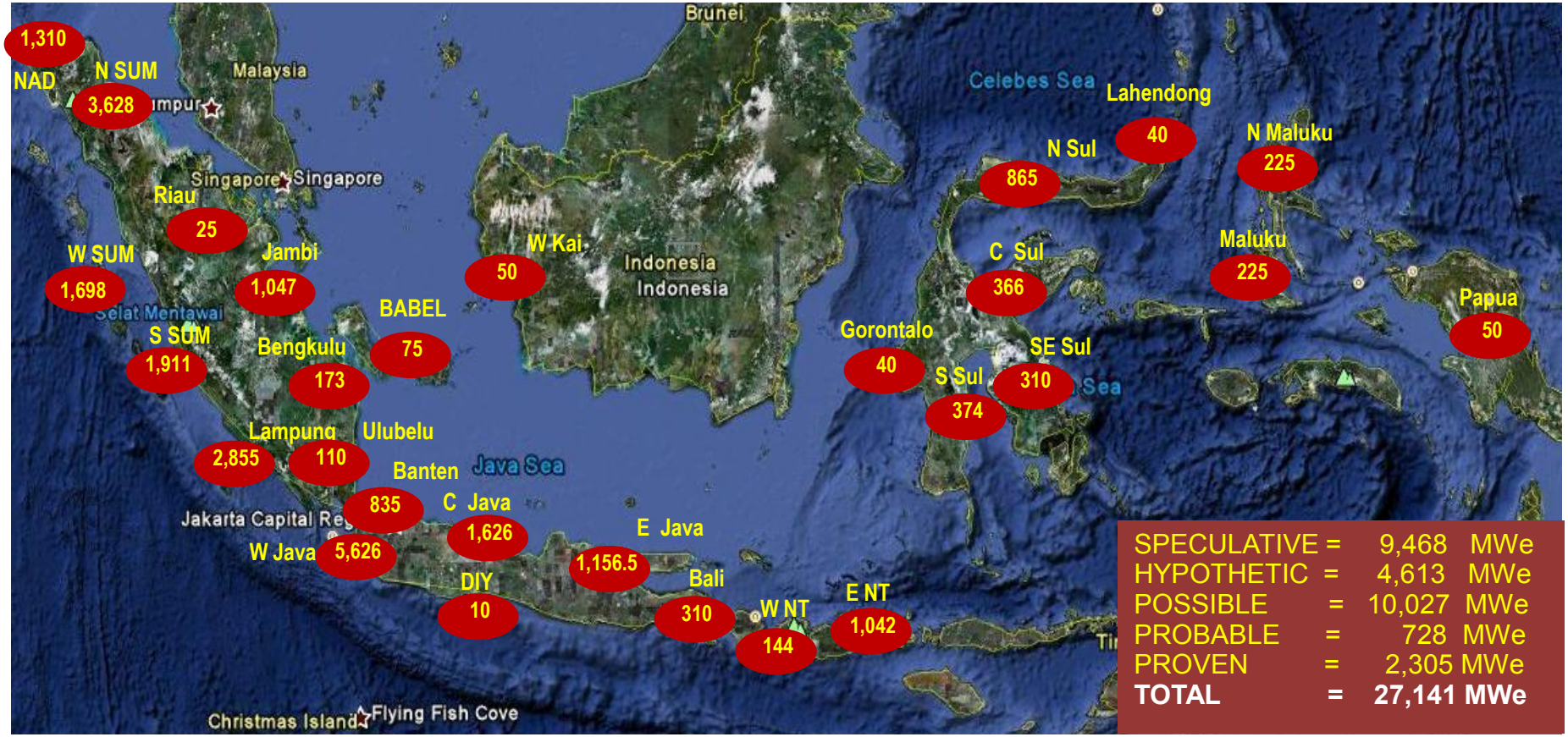
- Reliable source (non-intermittent)
- Energy security
- Hedge against commodity price volatility

ENVIRONMENT

- Global Greenhouse Gas (GHG) Impact
- Reduces local pollution

Indonesia's World Leading Geothermal Prospects

ENERGY GEOTHERMAL POTENTIAL (MWe)



Why has there been so little Geothermal Development in Indonesia?

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Key Barriers to Geothermal Development in Indonesia

Incremental (Additional) Costs

The financial cost of geothermal development is higher than the cost of developing an equivalent base-load substitute (i.e. coal), particularly when environmental impacts are not considered.

Geothermal Resources Risks

There are indications that Indonesia's geothermal resource risk is not excessive, but it is something inherent in the sector worldwide

Power Off-Take Uncertainty

The PLN credit/off-take risks due to its heavy reliance on GoI is seen as a considerable risk to all IPPs, including geothermal

Domestic capacity for conducting credible transactions

Limited government experience in conducting credible competitive tenders in a transparent manner as per Geothermal Law. As a result, no geothermal tender has reached financial closure thus far

These barriers make it a challenge to mobilize momentous investments of $10-$12 billion for achieve GoI target

Bank-IFC has Joint Strategy to assist with Geothermal Development in Indonesia

Geothermal Sector Reform

GEF Grant
(under implementation)

- Enhance policy framework by:
  - Pricing & Incentives
  - Upstream Risk Mitigation
  - Legal & policy review and amendments
- Transactions to tender projects for development
- Long-term domestic capacity building (w/Govt. & PGE)

Also supported by funding from PPIAF, ASTAE, ESMAP, INIS (AusAID), IDF

Investment Lending

Investment Loan to PGE
(under implementation)

- Kick-start PGE program(50 MW)
- Financing package from **IBRD** and **CTF** ($300 million)
- TA : institutional strengthening & capacity building (**NZ Grant**)

Drilling Finance/Resource Confirmation Project
(under identification)

- Exploration and Production Drilling for large-scale expansion

IFC financing for Private Developers
(under identification)

- $4 mil. risk capital, identifying reg. & internaitional developers

Carbon Finance

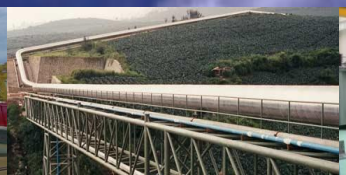
Lahendong II CDM Transaction
(under implementation)

- Purchase CER from PLN for 20 MW geothermal project

Technical Assistance to MEMR
(completed)

- TA related to Carbon Markets and accessing revenues under CDM

Pertamina Geothermal Energy (PGE):
Geothermal Clean Energy Investment Project



PGE aiming to become World Class Geothermal Developer

- Formally established in 2006, a subsidiary of Pertamina
- Has rights to **15** Geothermal Business Working Areas (WKPs), 9 PGE operated, 5 JOC, and 1 JV
- **292 MW** currently in own operation
- Revenue from sale of **steam**, **electricity** and allowance for **managing JOC** w/ private developers
- **Vision:**

  2008 – Business oriented

  2011 – Center for Geothermal Excellence in Indonesia

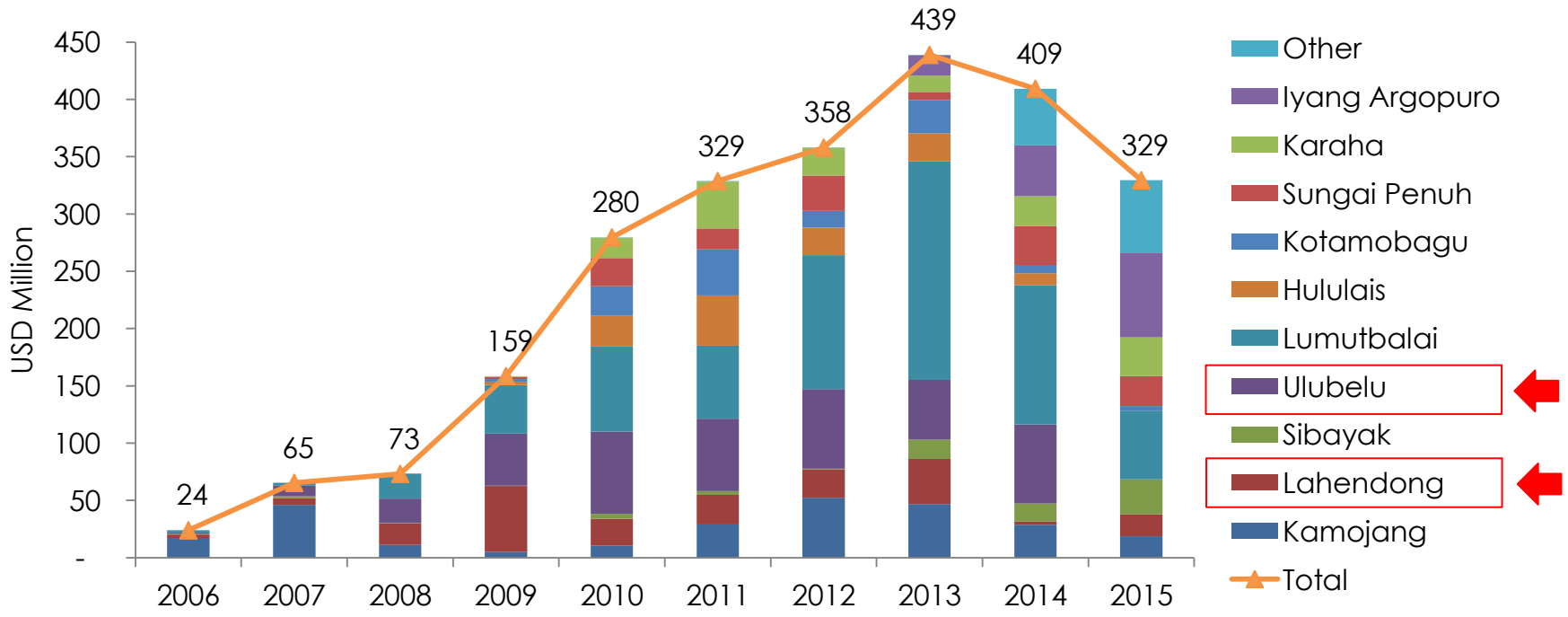
  2014 – World Class Geothermal Energy Enterprise

PERTAMINA GEOTHERMAL ENERGY

PGE Undertaking World's Largest Geothermal Expansion (1,000 MW)

PERTAMINA GEOTHERMAL ENERGY

Capital Expansion Program



Cumulative Capacity (MW)	172	172	252	272	272	292	402	832	1,092	1,322

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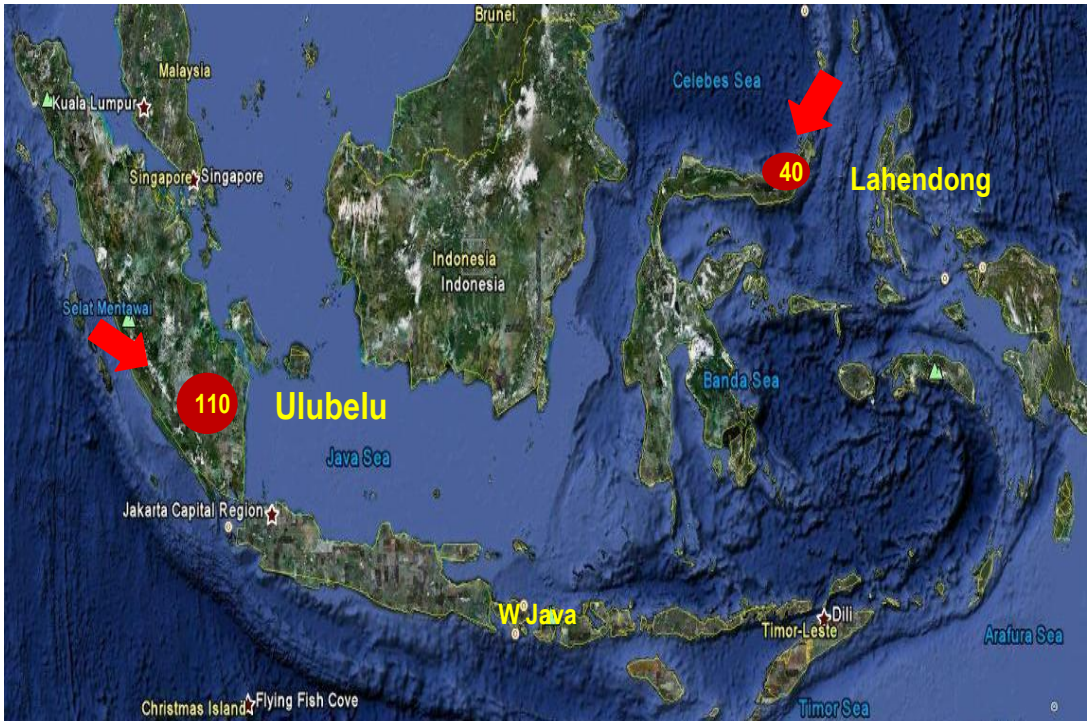
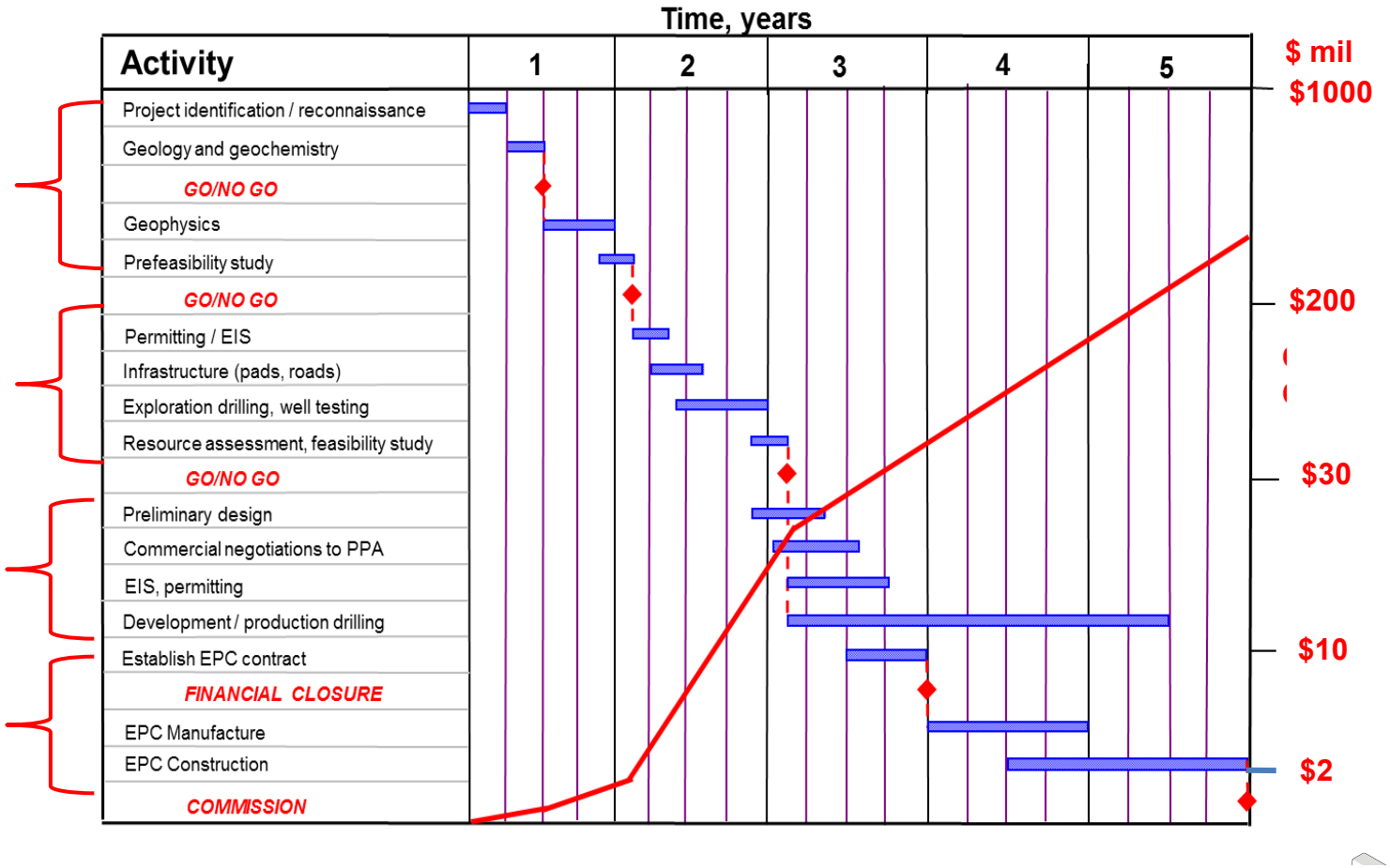
Focus of Presentation

- Utilization of geothermal resources
- Project feasibility
- Environmental impacts
- Land acquisition



Assessing Geothermal Resources



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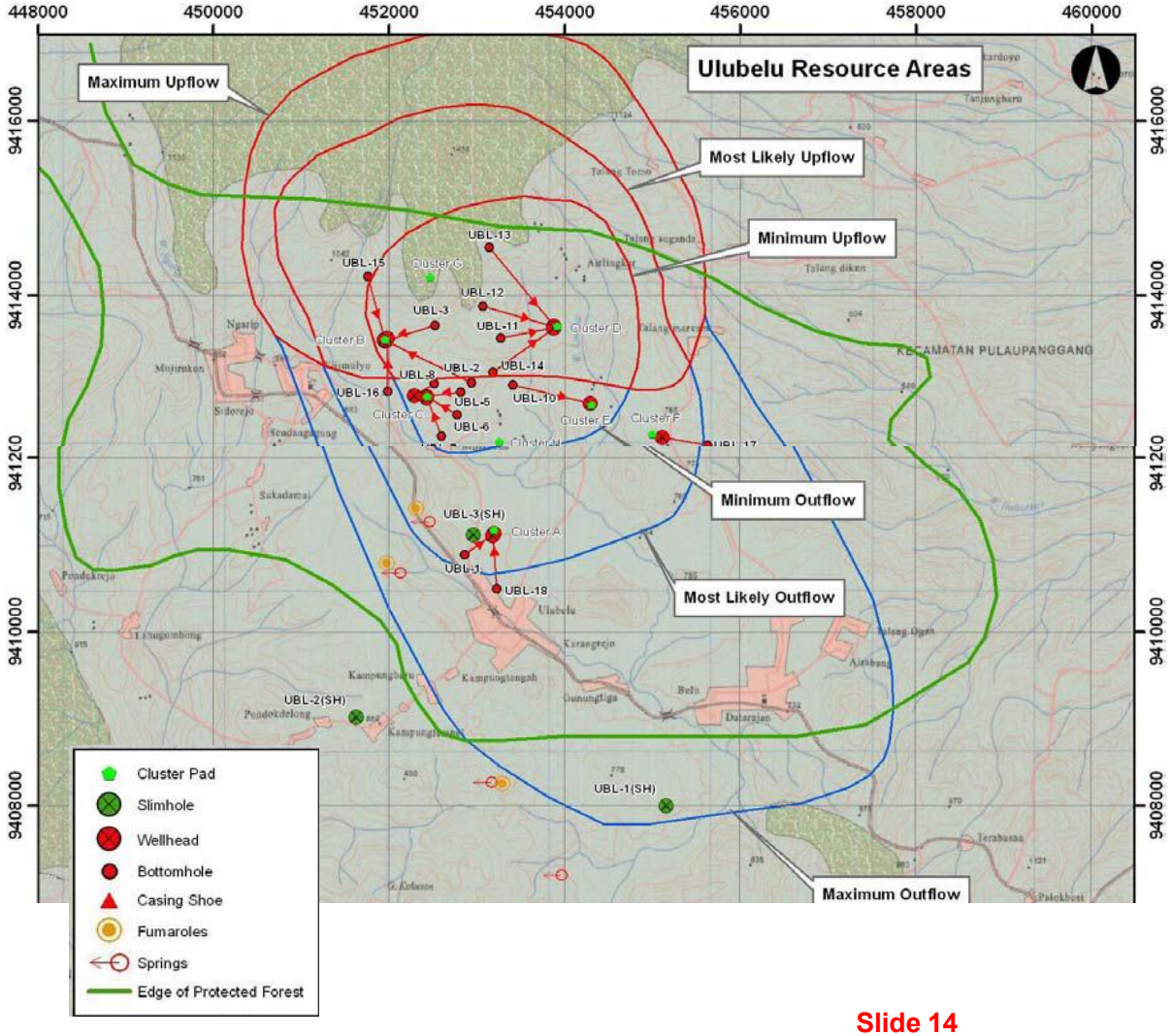
Observations on PGE Drilling Program

- Drilling Concepts were generic
- Conservative approach to confirmation of resources
- Considerable drilling but limited discharge and testing
- Inconsistent data collection – archiving - analyzing
- Poor well targeting and design

Ulubelu Geothermal Field



- Located in Sumatra Island
- WB Financing UBL Units 3&4– 110 MW
- Temperatures >280C
- 7.6 MW @ 6 kscg sep. pressure
- 16 Production Wells

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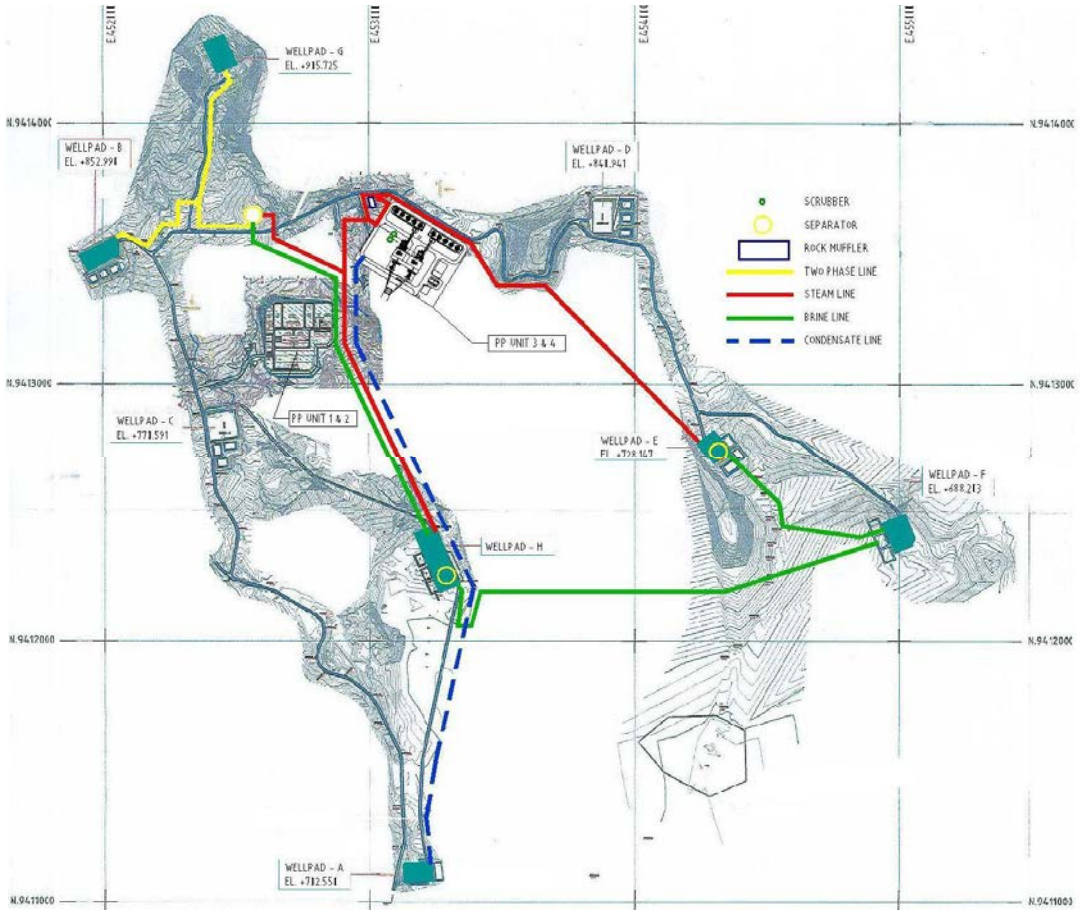
Ulubelu Geothermal Field



- **UBL Units 1&2 – 110 MW Power Plant by PLN**
- **26 KM T-Line for Units 1&2**

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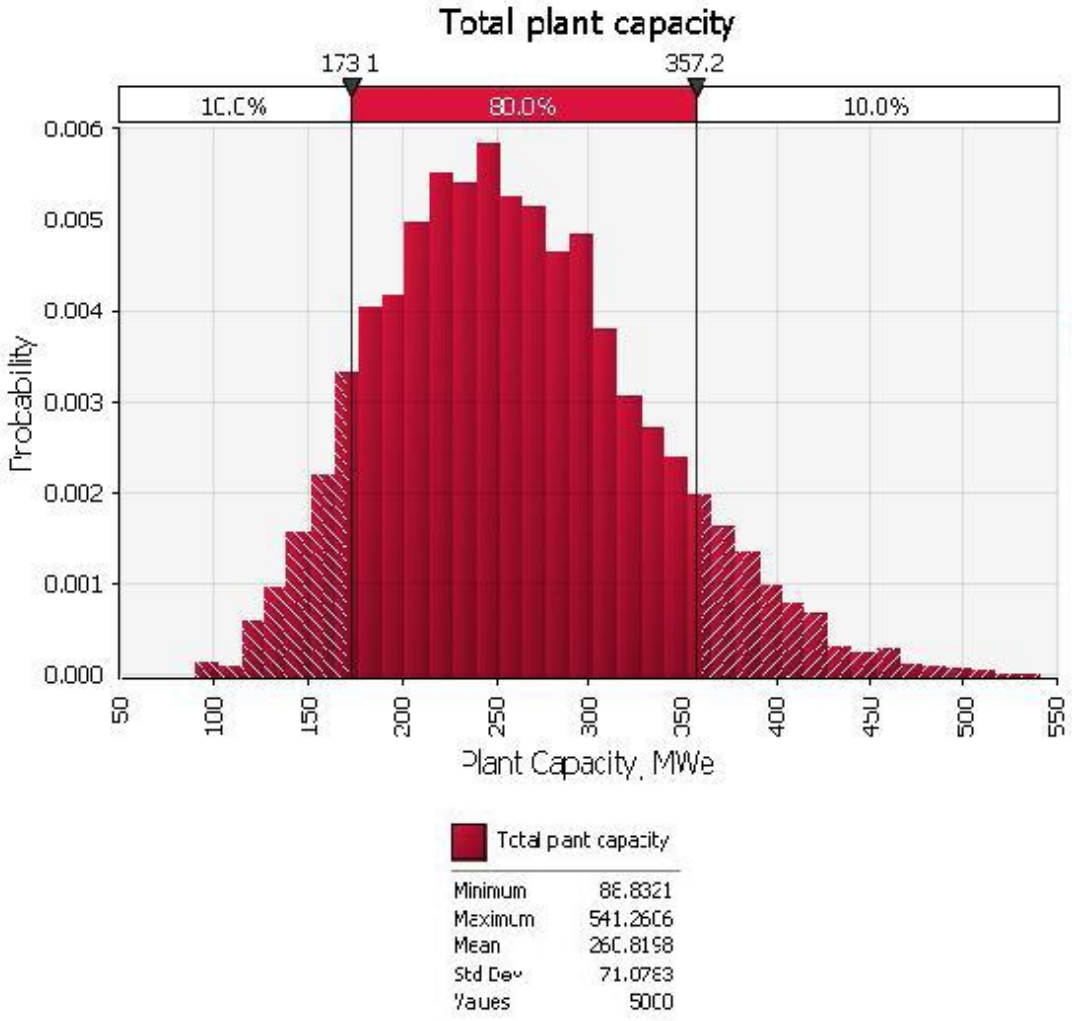
Resource Confirmation at Ulubelu



- **Stored Heat Calculation**
- **P50 – 255 MW**
- **P90 – 183 MW**
- **Confirmed Resources for UBL 3&4 – 73 MW @ 90% confidence**

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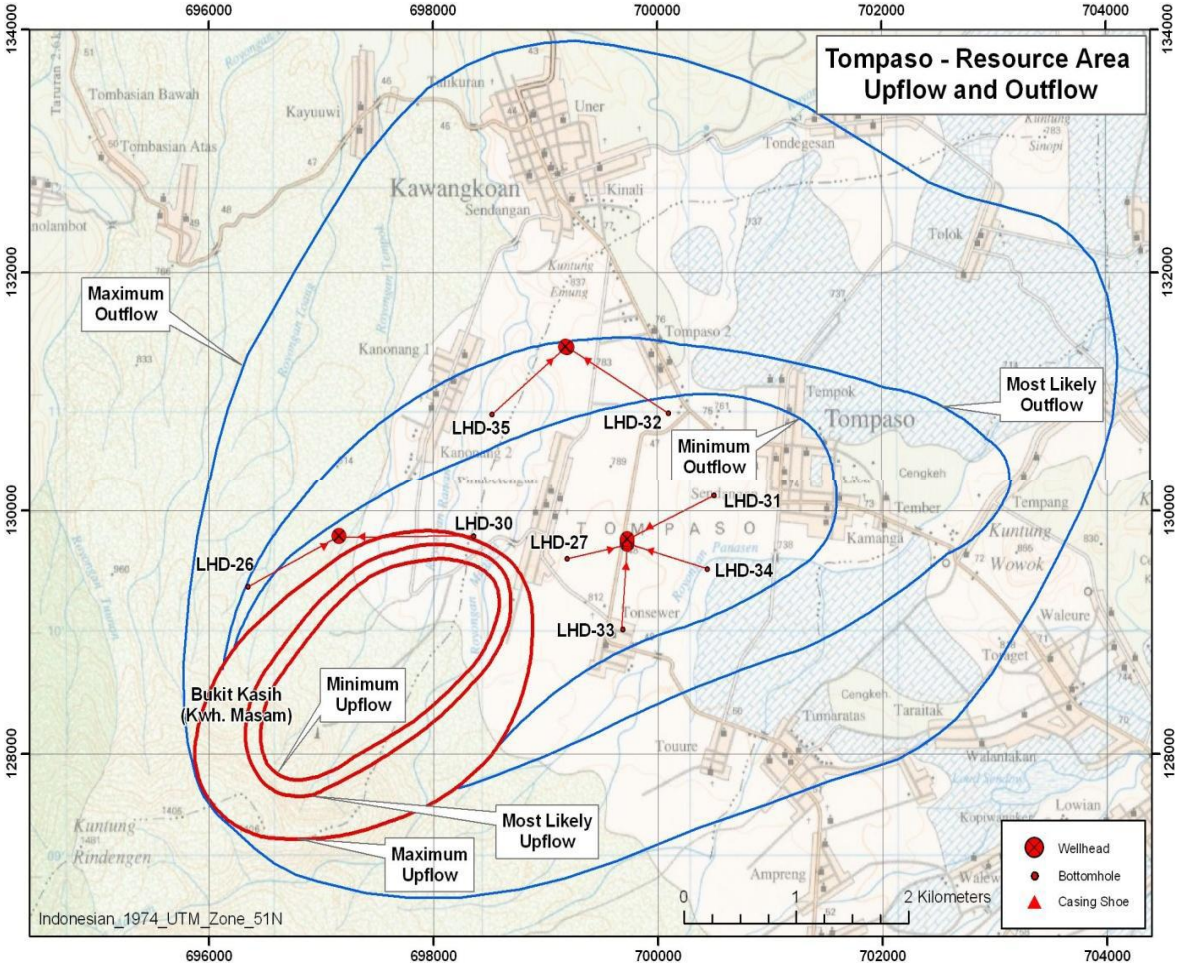
PROJECT: Lahendong (Tompaso)



- Lahendong WKP, Tompaso field
- WB Financing LHD Units 5&6
- Temperatures >310C
- 3.7 MW @ 7 kscg separation pressure
- 13 Prod. Wells

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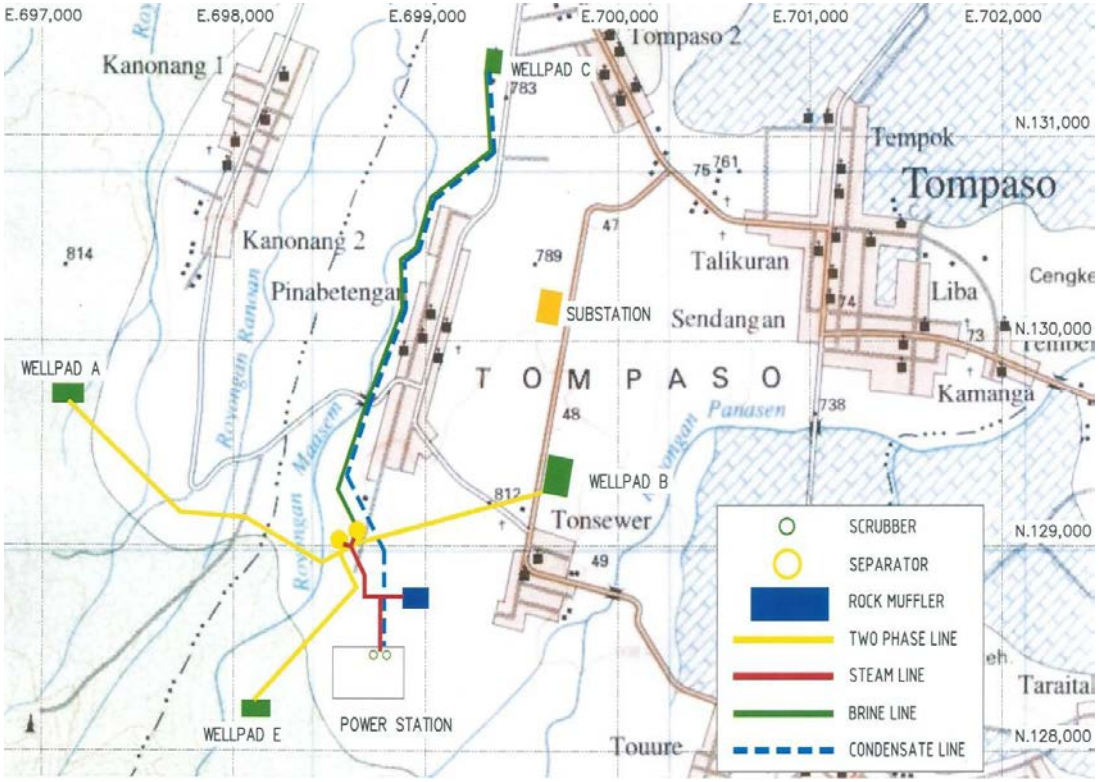
PROJECT: Lahendong (Tompaso)



- Near Manado load center
- Existing substation for Units 1-4

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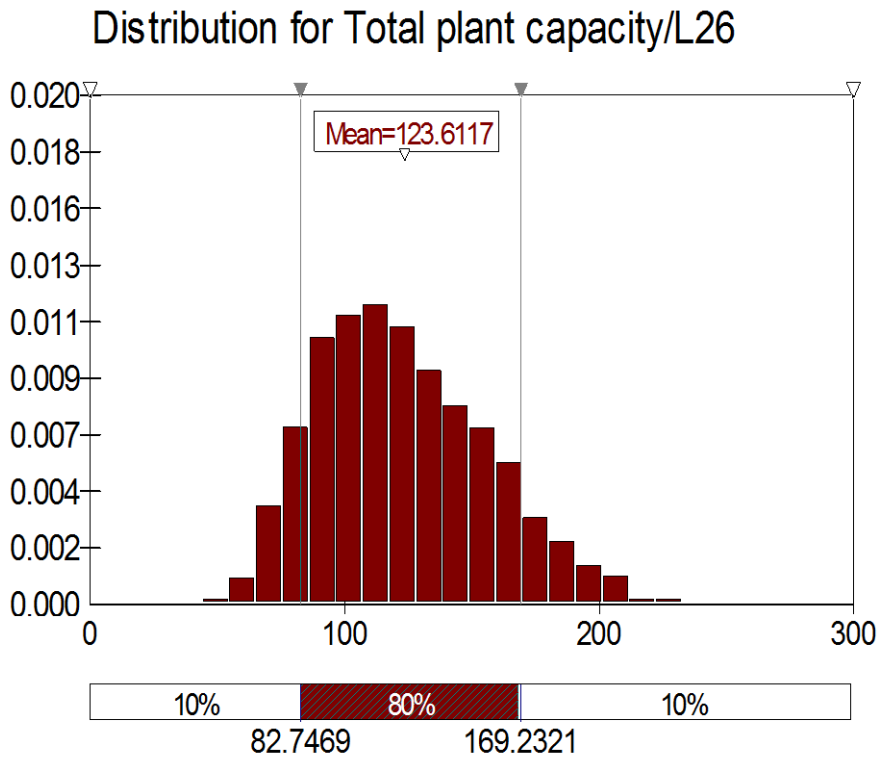
PROJECT: Lahendong (Tompaso)



- **Stored Heat Calculation**
- **P50 – 123 MW**
- **P90 – 83 MW**
- **Sufficient Resources Confirmed for LHD 5&6**

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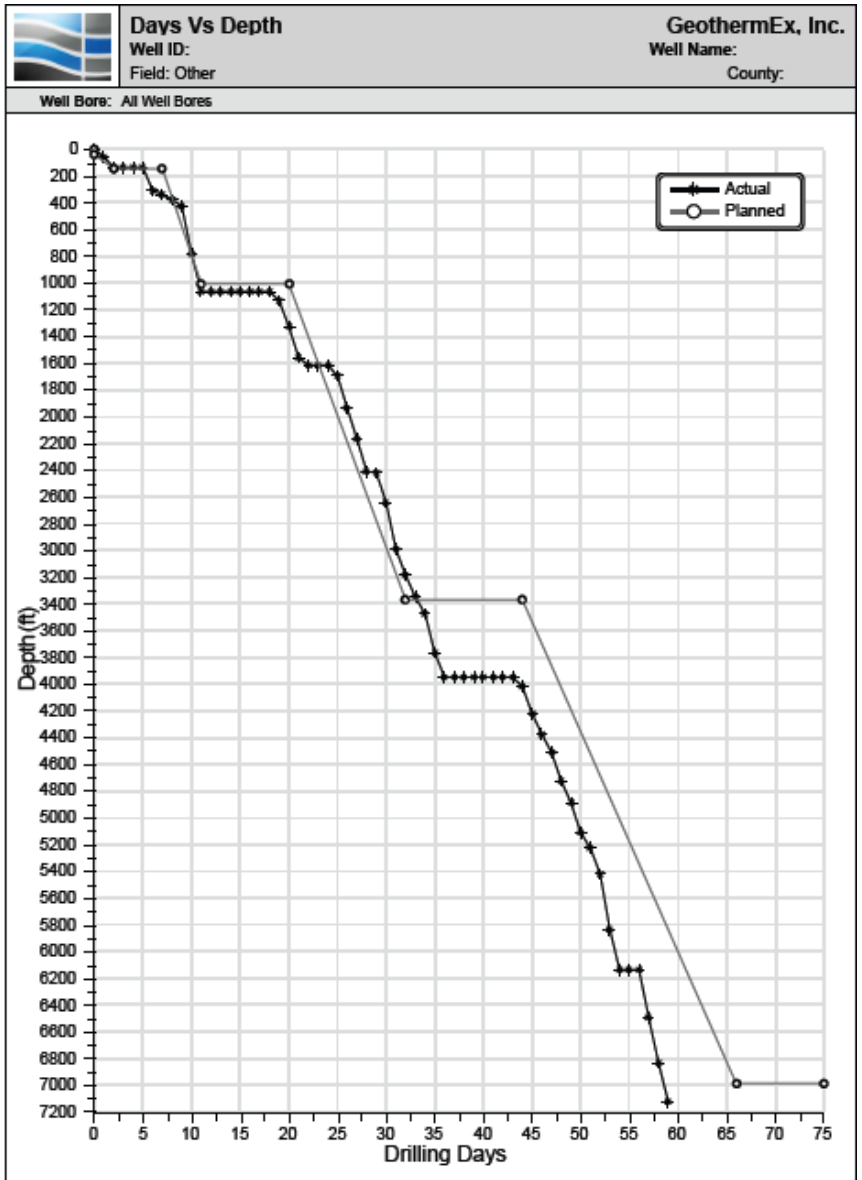
Proposal for Drilling Financing



- Drilling is complex
- 20-30 inter-dependent contracts
- Require flexibility in contract management
- WB procurement processes could introduce risk

Proposal for next project

- Achieve “economy” & “efficiency”
- Limited ICB, extensive use of existing PGE systems (NCB)
- Results based disbursement against verified Plan

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PROJECT: Kick-Start PGE Investment Program and help it become Premier Geothermal Developer

Steam field Development

$275 million

Steam Gathering (SAGS)

$50 million

Power Plants

$250 million

Institutional Strengthening

$7 million

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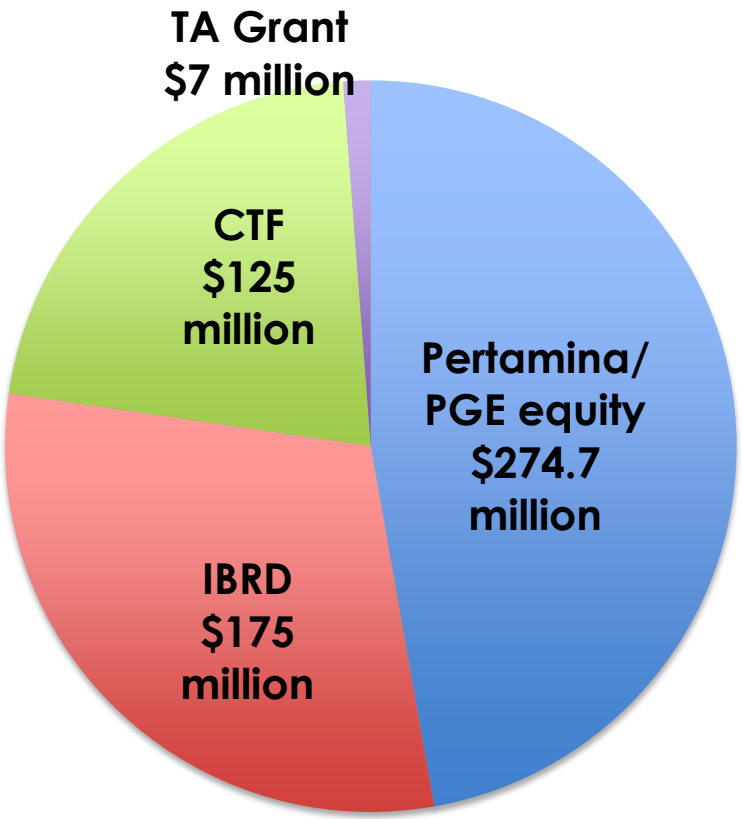
Project Financing



Pertamina/PGE own funds

- $ 274.7 million
- Return on equity - 14%

PERTAMINA GEOTHERMAL ENERGY

IBRD

- $175 million
- LIBOR + 0.48%
- 24.5 year tenor, 9 year grace

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CTF

- $125 million
- 0.25% fixed
- 40 year tenor, 10 year grace

CIF

TA Grant

- $7million from the Government of New Zealand

Government of New Zealand

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Integrated Approach to Project Evaluation

D. Sensitivity & Risk Analysis

A. Financial Analysis

- Macroeconomic Forecasts
- Project Parameters
- Cost Tables (Investment, O&M, taxes)
- Nominal and Real Cash Flows (TIP/Equity)

B. Economic Analysis

- National Economic Parameters
- Basic Conversion Factors
- Economic Cost of Geothermal and Avoided Cost (i.e. coal)
- Economic Resource Flows

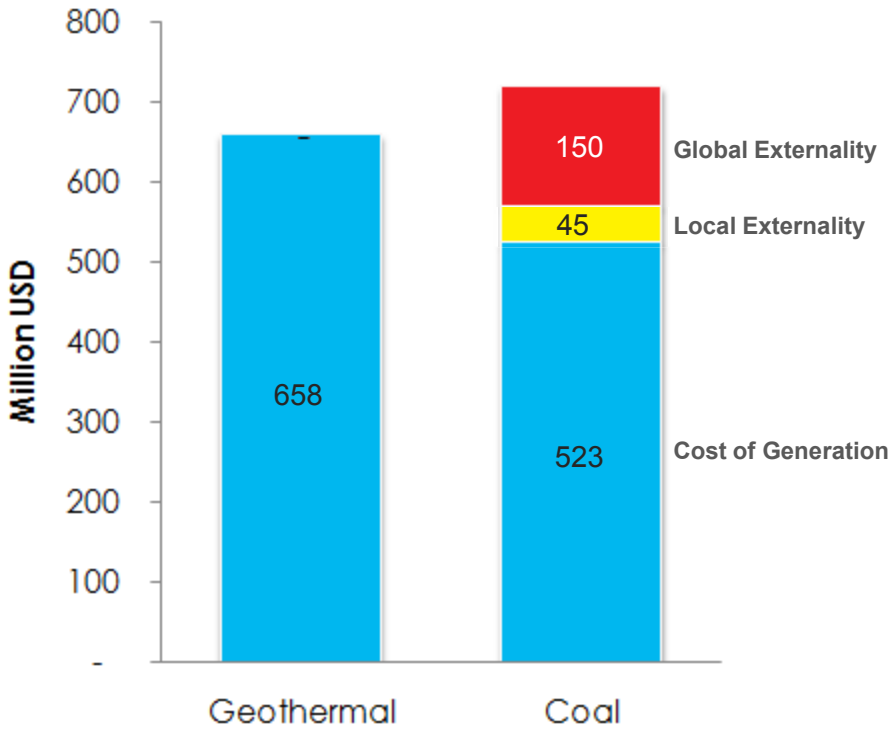
C. Stakeholder Analysis

- Externalities=PV of Economic Resource Flows – PV of Financial Resource Flows
- Net Resource Flows of Externalities and Allocation of Externalities

Project Economically Justified when Local and Global Externalities are Considered

PV of Economic Costs: Geothermal vs. Coal

(at 10 % social discount rate)



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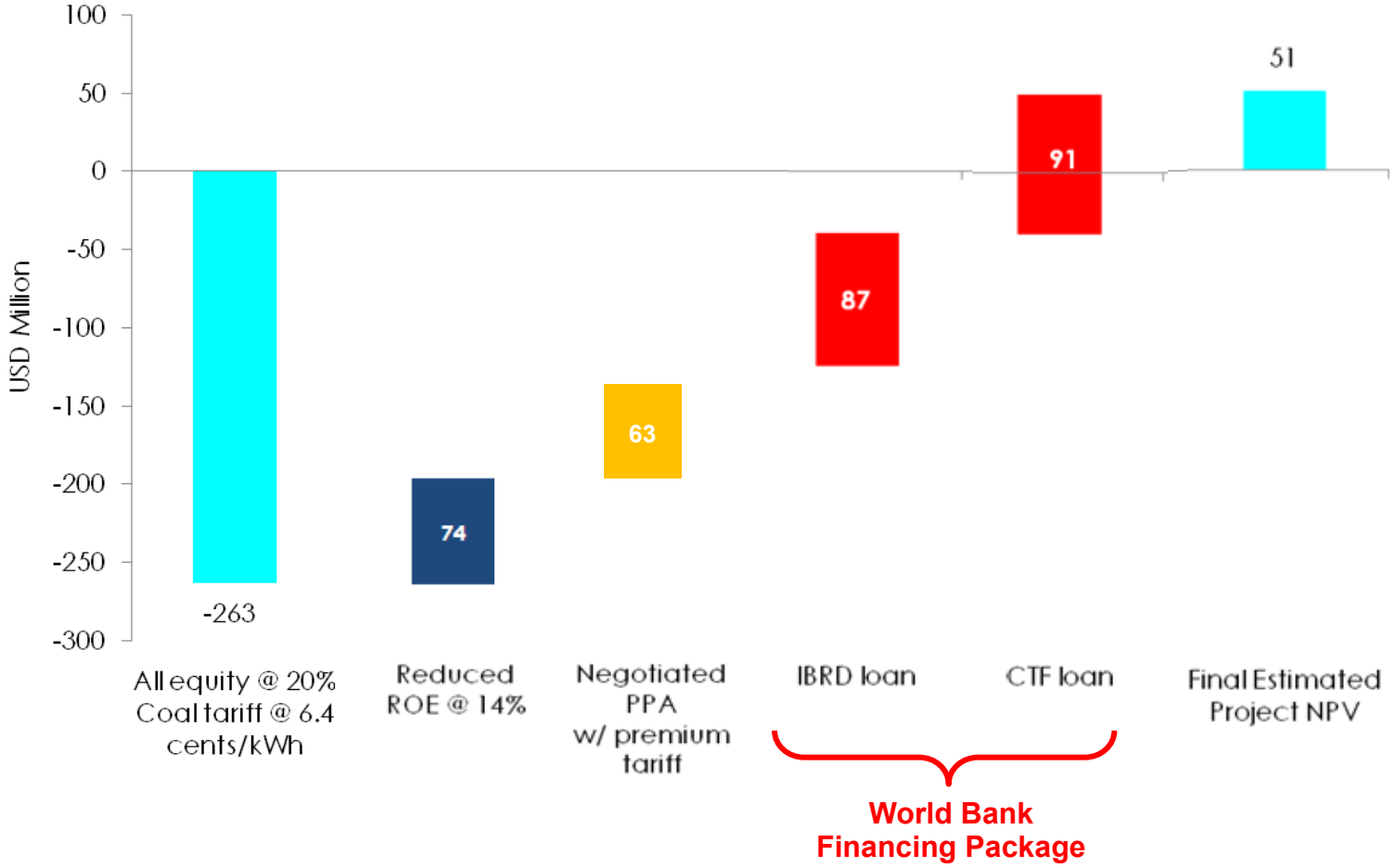
Engineering a Scheme to Bridge the Financial Viability Gap

Net Present Value from PGE's Equity Point of View



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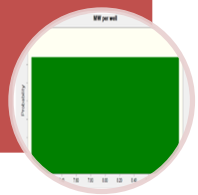
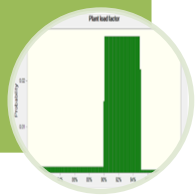
Risk Variables for Monte Carlo Simulation

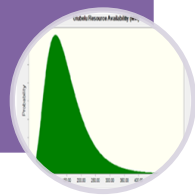
Well Productivity - Ulubelu & Lahendong



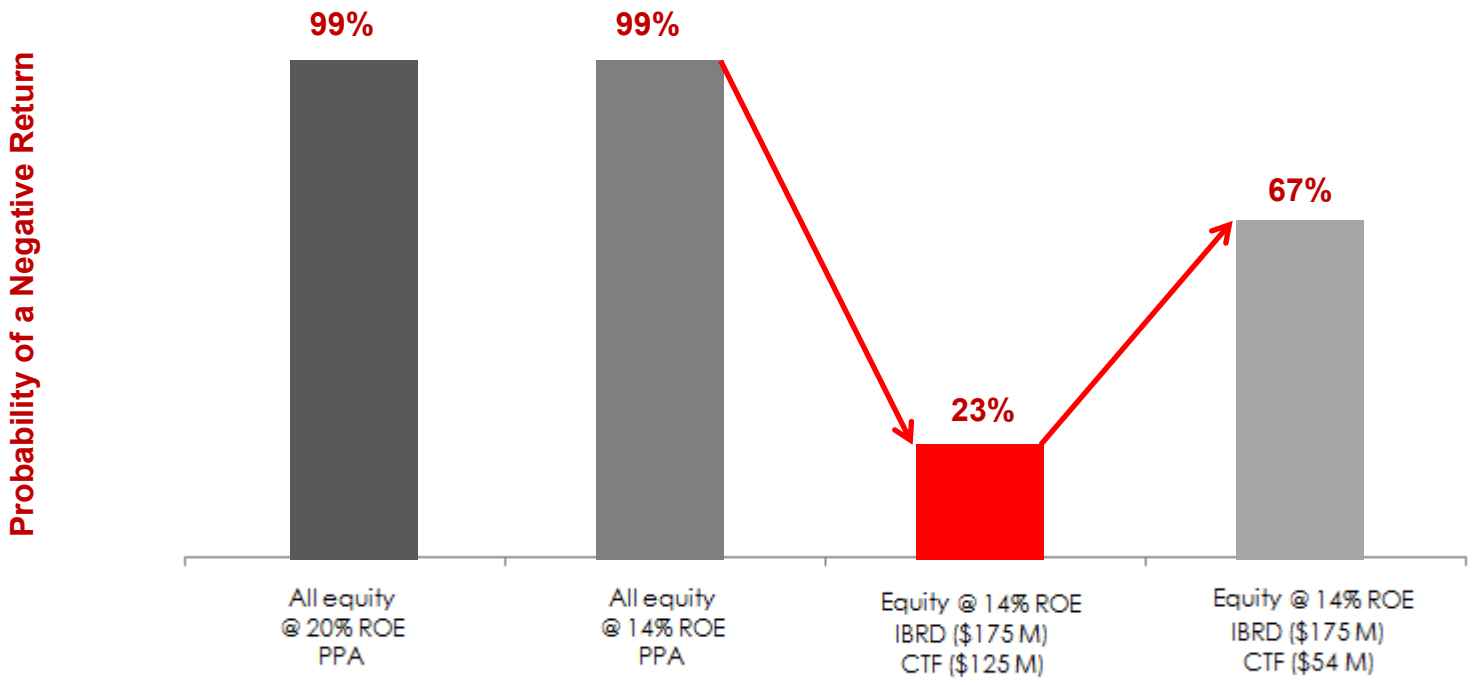
Geothermal Plant Factor - Ulubelu & Lahendong



Resources Availability - Ulubelu



Robustness of Project is Critical to Taking on Investment Risks



Probability of loss > US$ 50 million	99%	98%	2%	23%

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Summary of Financial Scenarios from PGE's Equity Point of View

	Financial metrics	Ulubelu	Lahendong (Tompaso)	Combined Project
PGE all equity financing @ 14% ROE (@ coal-based electricity price of US¢6.4 /kWh)	Nominal FIRR	9.0%	6.8%	**8.3%**
	NPV (US$ million)	-109.9	-79.0	**-188.8**
	Probability of negative return			**>99%**
PGE all equity financing @ 14% ROE (@ PPA tariff rates US¢7.53 /kWh for Ulubelu and US¢8.25 /kWh for Lahendong)	Nominal FIRR	11.0%	9.4%	**10.4%**
	NPV (US$ million)	-71.1	-55.8	**-126.2**
	Probability of negative return			**>99%**
PROJECT SCENARIO - with IBRD + CTF financing (@ PPA tariff rates US¢7.53 /kWh for Ulubelu and US¢8.25 /kWh for Lahendong)	Nominal FIRR	17.4%	14.6%	**16.5%**
	NPV (US$ million)	46.8	4.0	**51.4**
	Probability of negative return			**23%**

Stakeholder Analysis: Electricity to Consumers

Benefits of Additional Electricity

ELECTRICITY SUPPLY	Financial @ 10% EOCK	Economic @ 10% EOCK	Externality
Benefit from electricity supply	651	1,394	743

Benefit to Residential, Commercial, and Industrial Consumers

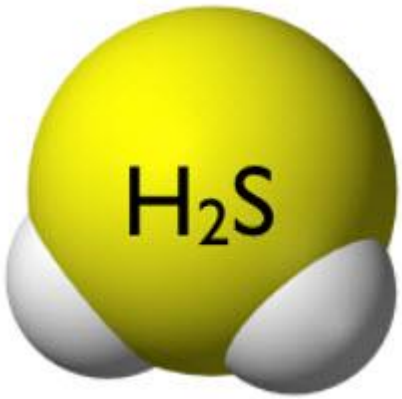
Stakeholder Analysis: Distributional Impact ("who gains and who pays?")

GEOTHERMAL GENERATION	Financial @ 10% EOCK	Economic @ 10% EOCK	Externality	Government	Local Community	Global Community
Revenue/Benefit	637	527	(109)	(109)		
Investment*	(454)	(493)	(39)	(39)		
Make-up wells*	(65)	(70)	(6)	(6)		
O&M*	(87)	(95)	(8)	(8)		
Tax	(84)		84	84		
Health benefit	-	45	45		45	
Reduction of GHG	-	150	150			150
Compensation through CTF Concessional Financing	86	-	(86)			(86)
				(77)	**45**	**64**

COAL-BASED GENERATION	Financial @ 10% EOCK	Economic @ 10% EOCK	Externality	Government	Local Community	Global Community
Revenue/Benefit	527	527	-			
Investment*	(207)	(225)	(18)	(18)		
Fuel cost*	(218)	(237)	(19)	(19)		
O&M*	(56)	(61)	(5)	(5)		
Tax	(38)	-	38	38		
Health benefit	-	-	-			
Reduction of GHG	-	-	-			
				(4)	**0**	**0**

Distributional Impact of Geothermal vs. Coal	**(73)**	**45**	**64**

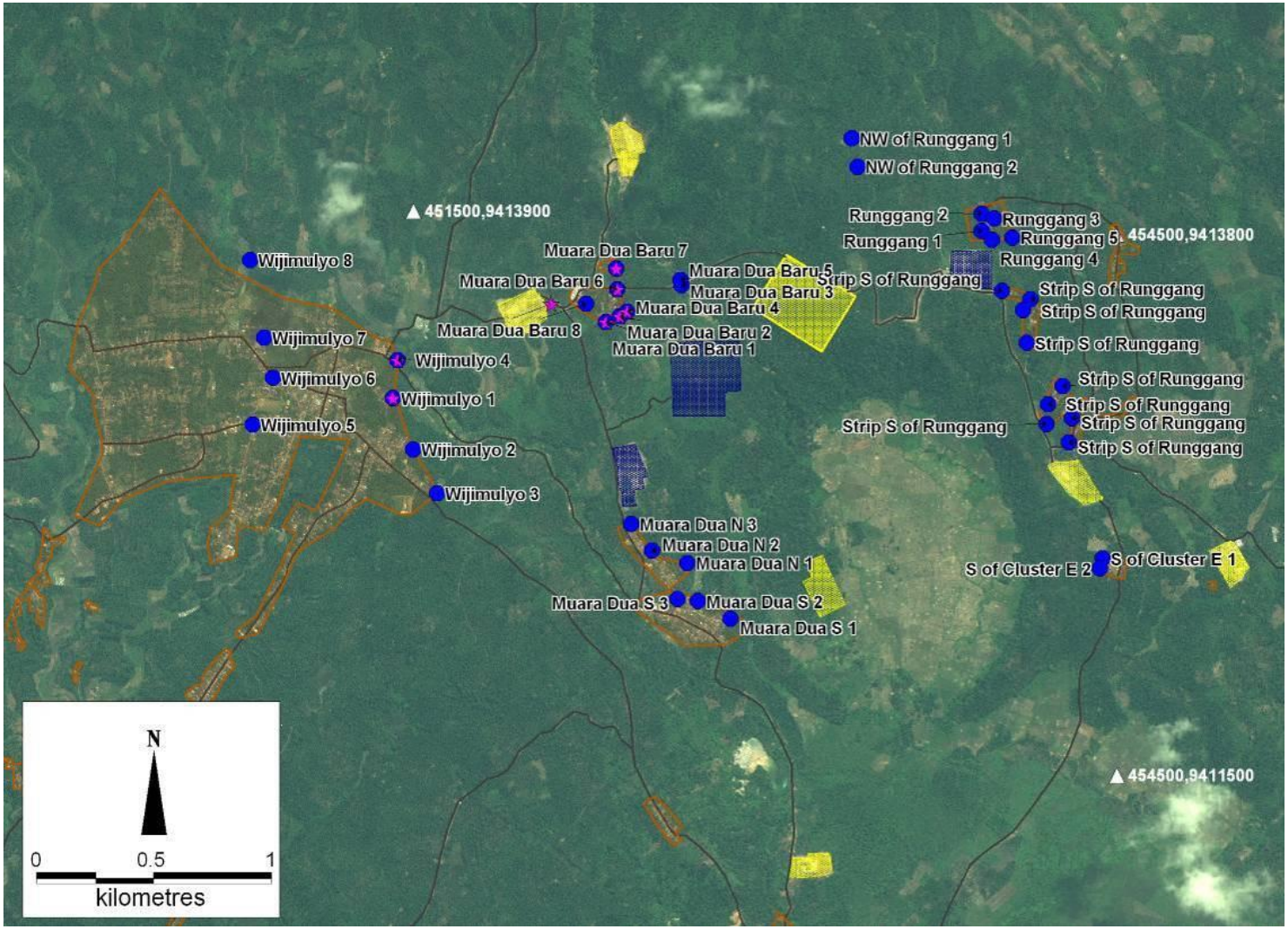
Health Impact of Non-Condensable Gas (NCG) Emissions



Hydrogen Sulfide (H_2S)

- **H_2S is a non-condensable gas (NCG), mainly exhausted at the cooling towers and also rock muffler**
- **Characteristics of H_2S are:**
  - Rotten egg odor recognizable at 6.7 micrograms/cubic meter (µg/m^3)
  - WHO health guideline – 150 µg/m^3 (24-hour average
  - Potentially lethal above 448,000 µg/m^3
- **GoI has emission limit for H_2S but no ambient health standard**
- **WB Group General EHS Guidelines**

Ulubelu Population Centers (Receptors)



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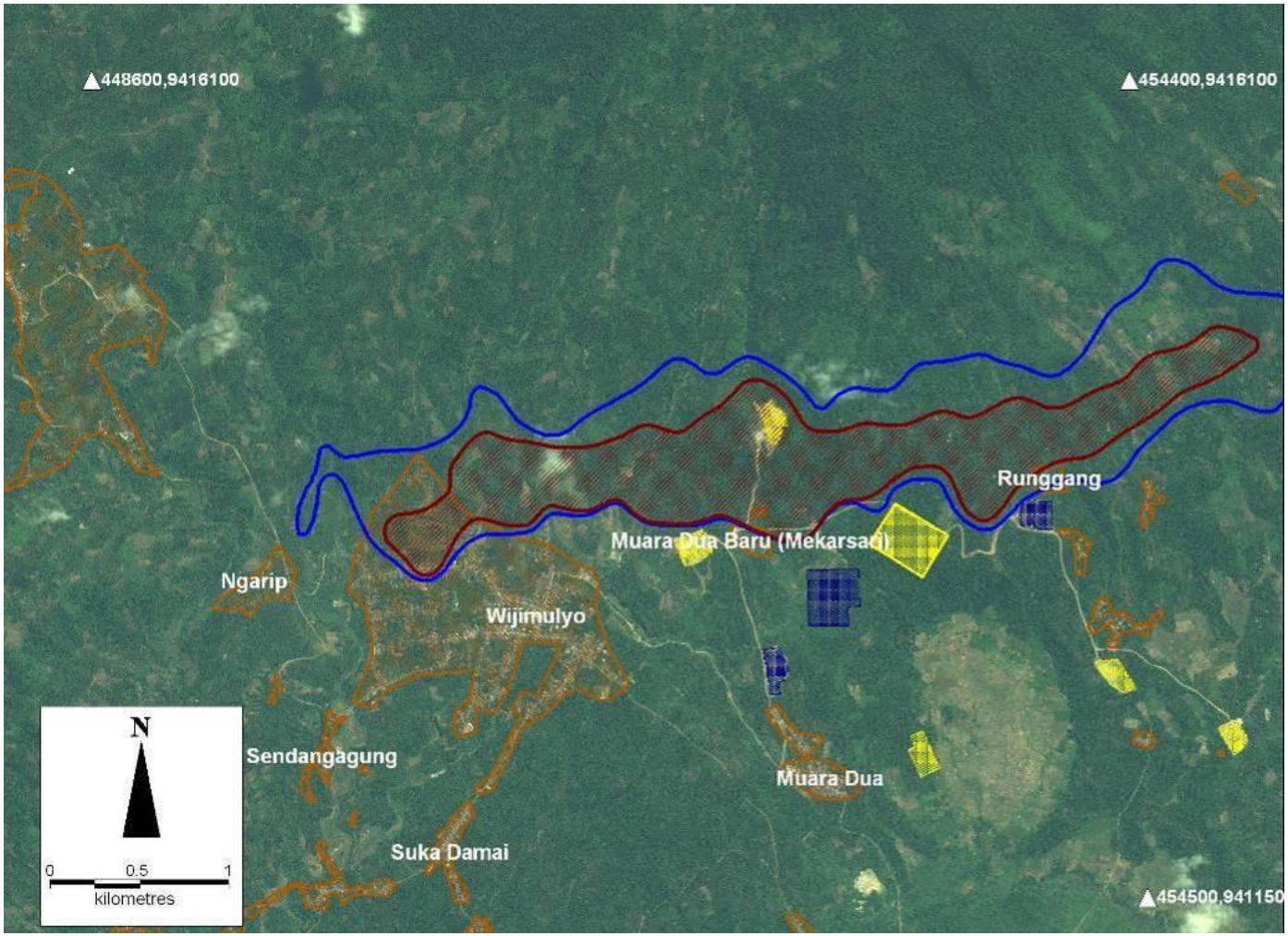
Dispersion of H_2S Emissions at Ulubelu



- 1.14 wt%
- 44 locations modeled
- 10 exceed standard based on PLN 1&2
- 17 exceed when 4 units in operation
- 60% abatement sufficient to meet WHO standards

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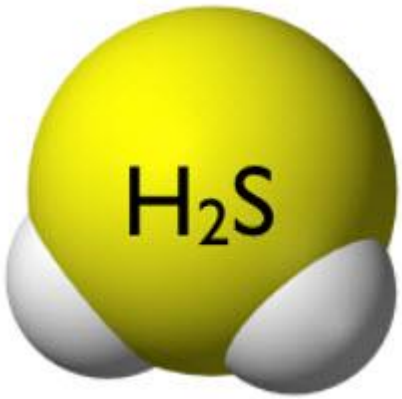
Addressing H_2S Emissions in Airshed



Joint H_2S Abatement Agreement (JHAA)

- **First-of-its-kind JHAA signed between PGE and PLN**
  - Consider Ulubelu as common airshed
  - Jointly monitor H^2S emissions
  - Include abatement as necessary to meet WHO health guideline – 150 µg/m^3 in airshed
- **Facilitated by GoI upon WB request**
- **Initiated national dialogue on H_2S emissions from geothermal**

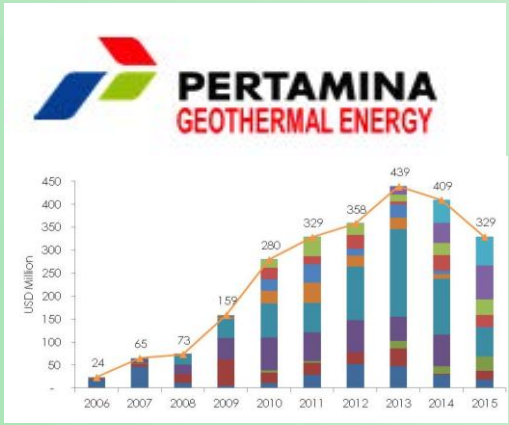
Voluntary Land Acquisition Approach

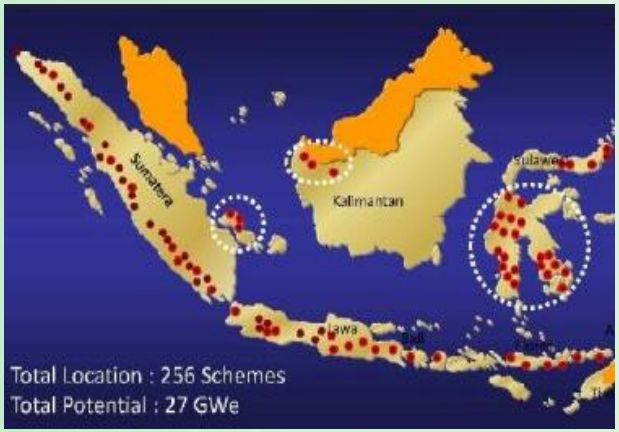
Land Acquisition and Resettlement Policy Framework

- Voluntary (willing-buyer willing-seller) approach avoids expropriations
- Non-confrontational, negotiated price agreements
- Relatively small land requirements, technology provides buyer with options
- Sellers have option to refuse sale

Kick-Started PGE's Transformation

150 MW → **1,000 MW** → **9,500 -27,000 MW**





Investment Lending + Capacity Building

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REFERENCES

- Project Appraisal Document: Geothermal Clean Energy Investment Project, World Bank

- "Geothermal Resource Risk in Indonesia – A Statistical Inquiry", Stanford University
- "Scaling-Up Indonesia's World Leading Geothermal Potential: An Integrated Approach to Evaluating a Green Finance Investment", Pending ESMAP and Duke University

- An Assessment of Geothermal Resource Risks in Indonesia, PPIAF
- Geothermal Diaries: The Journey of Developing the Ulubelu and Lahendong Geothermal Fields in Indonesia, pending ESMAP

Thank You

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